IPSC

INTERMOUNTAIN POWER SERVICE CORPORATION

Condensate Pump System Study

Project Title: U1 & U2 Condensate Pump VFD Installation Date: February 25, 2009

1. Introduction: U1 and U2 condensate pump systems are each comprised of three (3) parallel pumps that take condensate from the hot-well up to the De-aerator on the 13th floor then up to the boiler drum on the 18th floor. At full load (950 MW) operators run two (2) of the three pumps at full speed. It is proposed that a significant amount of auxiliary power can be saved by installing variable frequency drives on the three (3) condensate pumps. Contractor shall perform a system study on the existing condensate pump system in order to reveal how much, if any, auxiliary power can be saved. Pump, motor, and piping data shall be provided by IPSC. Contractor shall be responsible for physical measurement of existing piping system.

2. Contractor shall provide an updated system evaluation: Contractor shall evaluate the performance characteristics of the pumps for single, dual and triple pump operation at the following unit loads (20, 40, 50, 75, 90 and 100 percent load). This adds up to 18 scenarios that Contractor shall provide full system curves and pump performance characteristics.

    a. Contractor shall evaluate and update the pump performance and system curves:

        i. All piping lengths, bends and radii shall be used to produce the updated system curve. The updated curve shall show Head as a function of Flow.

            (1) Contractor shall show all calculations so IPSC shall be capable of review.

            (2) Contractor shall evaluate system for all 18 scenarios and include a system curve for all variations of bypass openings in piping system.

        ii. Existing pump curves shall be updated: For all the following curves Contractor shall superimpose the updated system curves onto the pump performance curves.

            (1) Contractor shall provide the array of pump curves for zero RPM to 1180 RPM.

            (2) Contractor shall provide updated efficiency curves for the pumps for all speeds.

            (3) Contractor shall provide updated break horsepower curves for the pumps for all speeds.

    b. Economic Evaluation: Contractor shall calculate the projected amount of Auxiliary Power Consumed with the use of variable frequency drives on the Condensate Pumps. Contractor shall show all mathematical formulas and shall discuss all reasoning behind formulas used.

        i. Results of Economic Evaluation Depend on VFD Drive Chosen: Contractor shall choose three (3) VFD available on the world market. Of these products Contractor shall use their efficiencies and performance characteristics to evaluate the economical benefits of installing VFD's on the Condensate pumps.

(1) One of the three (3) VFD's to be used shall be the Robicon ® Perfect Harmony VFD drive.

3. Over-Current Protection Coordination Update: As part of the installation of variable frequency drives the existing over-current protection on the condensate pump motor shall be modified. Contractor shall provide modified relay settings.

   a. System Protection Components: Contractor shall provide a recommendation for the following components:

      i. Instrument transducers: Current Transformers (5 amp secondary typical) shall be recommended.

         (1) Contractor shall include ratings, ratios, classifications and curves. CT secondary leakage impedance, CT excitation reactance, Maximum Impedance of terminating device (burden).

      ii. Time Delay Over-Current Relays: Contractor shall recommend new settings that will properly protect the cable to the variable frequency drive. Evaluation of over-current settings shall coordinate with the existing power system and discriminated against certain frequencies of current characterized by variable frequency drive performance (restraint).

      iii. Zones of Protection: Contractor shall provide the new "Zones of Protection" mapping recommended.

4. Pump Variable Frequency Drive Control: Contractor shall evaluate the control of the pump system and provide recommendations. The control of the system shall be evaluated for single, dual, and triple pump operation at 20, 40, 50, 75, 90 and 100 percent of unit load:

5. Contractor shall provide recommended VFD ratings: Ratings recommended by Contractor shall include the following:

      i. Reasoning,

      ii. Mathematical formula,

      iii. Standard(s) used for reference.

Generator Circuit Breaker Replacement System Study

Project Title: U1 & U2 Generator Circuit Breaker Replacement Date: February 25, 2009

Project Coordinator: Nathan R. Crop

1. Introduction: The Intermountain Power Project has two (2) each units. Each unit is equal in size and output (950MW). Both U1 and U2 Generators feed to their own step-up transformer and auxiliary transformers. The isophase bus between the Generators and corresponding transformers is identical in length and dimensions on both U1 and U2.

   a. IPSC plans to replace both the U1 and U2 Generator Circuit Breaker (GCB). Contractor shall investigate the new requirements regarding the following:

      i. Continuous current carrying capability

      ii. Short-circuit current interrupting capability

      iii. Out-of-phase current switching capability

      iv. Transient recovery voltage capability

      v. Rated maximum voltage

      vi. Rated dielectric strength

   b. Note that IPP Generator, isophase bus and connected transformer ratings are attached.

   c. Recommended ratings are dependant on GCB performance: All electrical evaluations and calculations shall assume the performance characteristics of two (2) different GCBs from two (2) distinct GCB manufacturers.

      i. Contractor shall provide manufacturer model and details for GCBs used in study.

      ii. One of the GCB models used shall be from ABB's SF6 line of self extinguising generator breaker technology.

   d. All ratings provided by Contractor shall include:

      i. Reasoning,

      ii. Mathematical formula,

      iii. Standard(s) used for reference.

         (1) Standards shall include but not be limited to the following:

            (a) IEEE Std C37.013-1997: IEEE Standard for AC High-Voltage Generator Circuit Breakers Rated on a Symmetrical Current Basis.

            (b) Canadian/American EMTP User Group: ATP Rule Book, 1987-1992.

e. Study Results:

i. Contractor shall provide the software used and the standards referenced for all calculations.

ii. Contractor shall explain all assumptions made and provide explanations for all constants. Assumed values shall only be made where information is not available.

iii. Contractor shall provide formulas, tables and graphs of the expected fault current that display the current versus time plot.

iv. Contractor shall provide formulas, tables and graphs of the expected fault voltage that display the voltage versus time plot.

2. Rated Continuous Current: Contractor shall provide the rated continuous current of the GCB.

3. Short-Circuit Current Rating: Two (2) different fault locations shall be evaluated as shown in this section.

i. Evaluate the system for system-source short-circuit current. This evaluation shall use the most comprehensive generator model available in today's software that includes all given impedances and ratings.

(1) Contractor shall evaluate fault current for both the unloaded and delivering power of (990 MVA @ 0.95 pf lag).

(2) The short-circuit current in case of a three-phase fault on the generator-side of the GCB.

(3) The short-circuit current in case of a line-to-line fault on the generator-side of the GCB.

(4) The short-circuit current in case of a single-line-to-ground fault on the generator-side of the GCB.

(5) The short-circuit current in case of a line-to-line-to-ground fault on the generator-side of the GCB.

ii. Evaluate the system for generator-source short-circuit current. This evaluation shall use the most comprehensive generator model available in today's software that includes all given impedances and ratings.

(1) Contractor shall evaluate fault current for both the unloaded and delivering power of (990 MVA @ 0.95 pf lag).

(2) The short-circuit current in case of a three-phase fault on the generator-side of the GCB.

(3) The short-circuit current in case of a line-to-line fault on the generator-side of the GCB.

(4) The short-circuit current in case of a single-line-to-ground fault on the generator-side of the GCB.

(5) The short-circuit current in case of a line-to-line-to-ground fault on the generator-side of the GCB.

b. Assumptions Contractor shall make for all fault current:

i. Fault to take place in the moment when voltage in one phase passes through zero.

ii. Calculations shall be based on the maximum service voltage of the high-voltage system (i.e. 345 kV).

iii. Faults shall be assumed to be Bolted (no arc-voltage at fault location).

c. Format of calculations carried out: Magnitude of the (symmetrical) short-circuit current and its degree of asymmetry (DC-component) shall be evaluated at the contact parting time of the GCB (delay of the protection system (assumed to be ½ cycle) plus opening time of the GCB). Evaluation shall assume the use of two (2) different GCB from distinct GCB manufacturers.

i. Contractor shall provide the system short-circuit current information as shown:

Item	**Calculated Value** (Fault-type 3ph, LL, LLG, LG)	
Contact Parting Time	[ms][1]	[ms][2]
Operating Voltage	[kV_{L-L}]	[kV_{L-L}]
Short-Circuit Making Current	[kA_{peak}]	[kA_{peak}]
Symmetrical Short-Circuit Breaking Current	[kA]	[kA]
Degree of Asymmetry (DC-Component)	[percent]	[percent]
Asymmetrical Short-Circuit Breaking Current	[kA]	[kA]

Instantaneous Maximum Voltage	[$kV_{peak-L-L}$]	[$kV_{peak-L-L}$]

[1]) Contact parting time of GCB type 1.
[2]) Contact parting time of GCB type 2.

4. Out-of-Phase Current Switching Capability: According to the IEEE Std C37.013 the out-of-phase current switching capability of a GCB is based on an out-of-phase angle of 90 degrees. An out-of-phase current switching capability based on a out-of-phase angle of 180 degrees shall additionally be evaluated.

    a. The fault current for both out-of-phase angles (90 and 180 degrees) shall be calculated.

        i. Contractor shall use a full comprehensive generator model in the calculations.

        ii. The out-of-phase condition (i.e. the faulty synchronism) shall be assumed to take place in the moment when the voltage in one phase passes through zero. The voltages on both sides of the GCB shall be set equal to the rated of the generator, i.e. to 26kV.

        iii. Contractor shall show in the study the magnitude of the (symmetrical) fault current and its degree of asymmetry evaluated at the contact parting time of two (2) distinct types of GCB's.

            (1) Delay of the protection system (assumed to be equal to ½ cycle) plus opening time of the GCB shall be part of the evaluation for the GCB ratings.

Item	**Calculated Value** (Fault-type 3ph, LL, LLG, LG)	
Contact Parting Time	[ms][1]	[ms][2]
Operating Voltage	[kV_{L-L}]	[kV_{L-L}]
Making Current	[kA_{peak}]	[kA_{peak}]
Breaking Current	[kA]	[kA]
Degree of Asymmetry	[percent]	[percent]
Asymmetrical Short-Circuit Breaking Current	[kA]	[kA]
Instantaneous Maximum Voltage	[$kV_{peak-L-L}$]	[$kV_{peak-L-L}$]

[1]) Contact parting time of GCB type 1.
[2]) Contact parting time of GCB type 2.

5. Open Circuit Faults:

    a. Contractor shall evaluate open circuit fault conditions to see if voltage ratings and current ratings will be effected. Results shall be shown in order to demonstrate that ratings shall not be affected by any open circuit fault.

6. Transient Recovery Voltage Rating: The parameter describing the transient recovery voltage (TRV) in case of System-source short circuit currents, Generators-source short-circuit currents, Load currents, Fault currents under out-of-phase conditions, respectively, are listed in Tables 5, 6, 8 and 9 of IEEE Std C37.013.

    a. Lightening and Switching Surges: Contractor shall evaluate the effect of both lightening at the secondary of the output transformers and switching surges in order to determine the maximum voltage expected at the GCB.

        i. Existing lightening or Surge arrester data is attached to these specifications.

    b. Contractor shall provide all transient recovery voltage ratings:

Case	MVA-Rating	Inherent TRV		
		Peak Value of TRV	Rate-of-Rise of TRV	Time Delay
System-Source Short-Circuit	[of XFMRS]	[$kV_{peak-L-L}$]	[kV/μs]	[μs]
Generator-Source Short-Circuit Current	[Gen]	[$kV_{peak-L-L}$]	[kV/μs]	[μs]
Fault Current under a 180 degree Out-of-Phase Condition	[Gen]	[$kV_{peak-L-L}$]	[kV/μs]	[μs]
Load Current	[Gen]	[$kV_{peak-L-L}$]	[kV/μs]	[μs]

7. Rated Maximum Voltage and Rated Dielectric Strength: Contractor shall provide the rated maximum voltage of the GCB. These ratings shall be from the result of the previous short-circuit studies. Generator voltage shall be plotted with time with respect to all short-circuit scenarios in order to determine the maximum voltage expected at the GCB.

    a. Lightening and Switching Surges: Contractor shall evaluate the effect of both lightening at the secondary of the output transformers and switching surges in order to determine the maximum voltage expected at the GCB.

    b. Contractor shall provide:

i. Rated power frequency withstand voltage (dry): _______[kV/1 min].

ii. Rated impulse withstand voltage (full wave): _________[kV_{peak}].

8. Conclusion Section of Study:

a. Contractor shall list minimum required ratings for the new GCB as conclusion to the study.

i. Along with minimum required ratings Contractor shall list available GCB's available in today's world market that would meet the requirements.